Intraventricular Delay and Blocks

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KEYWORDS

• Bundle branch block • Left bundle branch • Right bundle branch block • Hemiblocks
• His Purkinje disease

KEY POINTS

- Diseases affecting the His Purkinje system will alter the propagation of the electrical wave front in left and right bundle.
- Changes in propagation will induce vectorial shifts recorded on the 12-lead electrocardiogram (ECG) with changes often diagnostic of a specific bundle branch block.
- Delays or blocks of conduction can minimally involve a bundle branch or one of its subdivisions or be widespread, affecting different segments of both branches.
- Analysis of the ECG can often assess the severity of the injury but is limited in its ability to predict long-term risk of complete heart block or death.
- ECG limitations also include anatomic localization of some ECG abnormalities and distinction among conduction blocks and delays.

INTRODUCTION

The specialized tissue conducting cardiac impulses from sinus node, to the atria and to the ventricles comprises the 3 following anatomic regions (Fig. 1):

1. The atria
2. The atrioventricular (AV) junctional region (AV node and the nonbranching portion of the His bundle)
3. The branching of the His Purkinje system (HPS) into right and left bundle (LB) with its anterior, posterior subdivision and terminal arborizations.

The significance of conduction block in either bundle was recognized more than 100 years ago by observing electrocardiographic (ECG) tracings following experimental destruction of each branch. Further human and animal studies, including accurate endocardial and epicardial mapping, allowed the identification of changes in electrical wavefront propagation during left and right bundle branch block (LBBB and RBBB). The initial observations of vectorial shifts induced by conduction blocks were confirmed and expanded by these mapping studies.

It was observed that the main consequence of bundle branch block (BBB) is a profound alteration of activation of the ventricle supplied by the affected branch. A normally functioning HPS ensures fast and sequentially optimized wavefront propagation. In BBB, the intact bundle activates the muscle in a physiologic manner, and from

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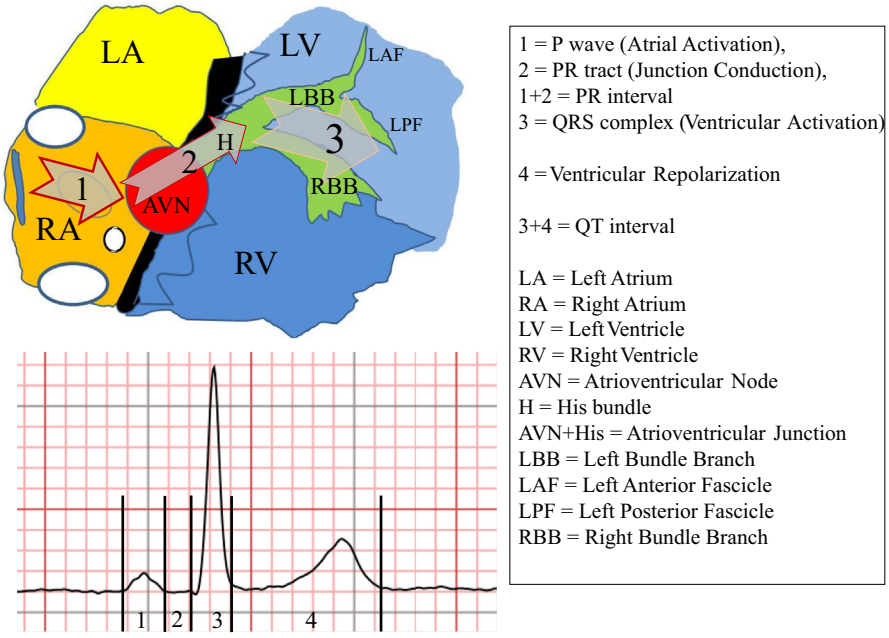

Fig. 1. The normal conduction system.

there the activation proceeds as a discontinuous wavefront to the affected chamber propagating from myocyte to myocyte. A marked decrease in conduction velocity and alterations in vector direction lead to the changes observed in the 12-lead electrocardiogram (ECG) often diagnostic of a specific BBB. As a result, the ECG is now considered the gold standard in the diagnosis of conduction disorders. Even so, limitations of ECG sensitivity and specificity in the diagnosis of conduction system disease need to be recognized and are discussed in this article.

Notwithstanding these limitations, several electrocardiographic criteria for intraventricular conduction defects were agreed upon and still constitute the most useful tool in the diagnosis of this condition (**Box 1**).

LEFT BUNDLE BRANCH BLOCK

Immediately after crossing the membranous septum, the common bundle of His divides into a right and a left branch coursing down both sides of the intraventricular septum from the base toward the apex. The LB begins below the noncoronary aortic cusp, thickening as it fans out with several unpredictable divisions variably interconnected, extending from the septum to the anterior and posterior wall of the LV (see **Fig. 1**). Variations in the anatomy of this branch are extensive, and there is no full agreement on the nomenclature of the different fascicles.

Nevertheless, an anterior and a posterior division are often identified as distinct fascicles with a variable number of fibers proceeding from the proximal portion of the anterior LB toward the basal third of the anterior left ventricular wall. Equally recognizable, a fan of LB fibers proceeds posteriorly after coursing one-half to two-thirds of the septum from the base to the apex. The existence of a separated third or septal branch of this bundle is still debated. In human and animal studies, a third radiation covering the midseptal surface was observed originating directly from the common LB or from a variable and convoluted plexus of ramifications from either the anterior or the posterior fasciculi.

Following Rosenbaum's observations, the concept of trifascicular left ventricle (LV) activation was enshrined in ECG literature. More than an anatomic observation, the division of LB in left anterior (LA) and left posterior (LP) fascicles conceptualized the fact that there is a clear anterior and a posterior vector in LV activation. During typical conduction, vectors balance each other, producing a QRS lasting up to 110 milliseconds with normal morphology. Any delay or "block" of conduction system ramifications supplying the anterior or posterior wall will lead to the ECG abnormalities defined as hemiblocks, as later discussed.

Conduction can be affected at multiple levels of the HPS, from its predivisional location in the common bundle of His to the terminal arborization.